FLIGHT

The AIRCRAFT ENGINEER & AIRSHIPS

First Aero Weekly in the World

Founder and Editor: STANLEY SPOONER

A Journal devoted to the Interests, Practice, and Progress of Aerial Locomotion and Transport

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DIARY OF FORTHCOMING EVENTS

Club Secretaries and others desirous of announcing the dates of important fixtures are invited to send particulars for inclusion in the following list:—

1926	
June 26–28	**Aerial Rally at Ostende.**
June 30	**Entries close (at ordinary fee) for Light 'Plane Competition, Lympne.**
July 2	**Entries close for King's Cup Race.**
July 2	**R.A.F. Dinner Club Annual Dinner, at Connaught Rooms.**
July 3	**Royal Air Force Display, Hendon.**
July 3	**Second R.A.F. Iraq Dinner, Hotel Cecil.**
July 8–24	**Royal Tournament, Olympia.**
July 9–10	**King's Cup Race, Hendon.**
July 11	**Lancashire Aero Club Display, Woodford Aerodrome.**
July 11–27....	**German Seaplane Competition at Warnemunde.**
July 19–Aug. 7	**French Competition for Multi-engined Seaplanes, St. Raphael-Frejus.**
July 31	**Entries close (at special fee) for Light 'Plane Competition, Lympne.**
Aug. 9–15	**French Light 'Plane Competition.**
Sept. 10–17	**Two-Seater Light Aeroplane Competition, Lympne.**
Sept. 18	**Grosvenor Challenge Cup, at Lympne.**
Oct.	**Schneider Cup Race at Norfolk, Virginia, U.S.A.**
Oct. 24–28	**Coppa del Mare, Italy.**
Nov. 11–15	**Coppa d'Italia, Italy.**
Nov.–Dec.	**Paris Aero Show.**

EDITORIAL COMMENT.

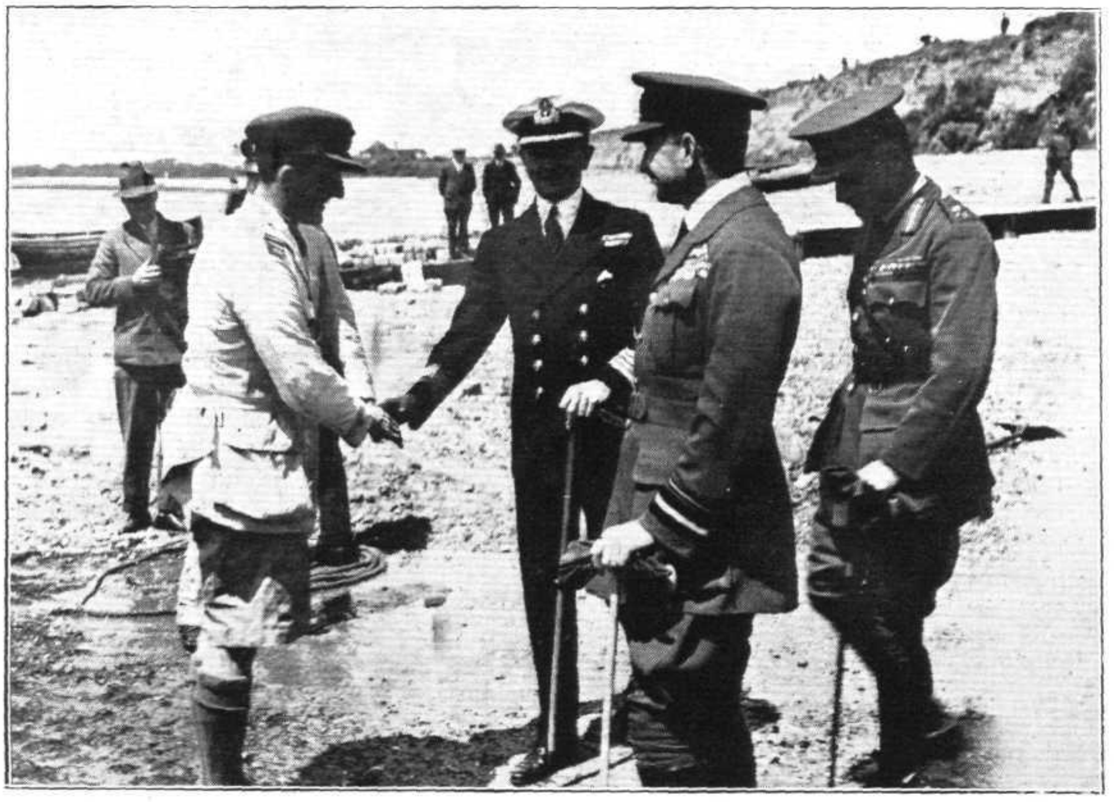
Cairo–Cape–Cairo–England

"THERE could be no more convincing demonstration of the assured future of aviation as a mobile and economical instrument of Imperial defence and as a reliable means of speeding-up communications between this country and the Dominions." This sentence, quoted from the t legram sent by Sir Samuel Hoare, Secretary of State for Air, to Wing Commander C. W. H. Pulford, O.B.E., A.F.C., p.s.a., Officer Commanding Royal Air Force Cape Flight, on the arrival of the squadron at Lee-on-Solent on June 21, expresses in the briefest possible form the immediate result of the R.A.F. flight from Cairo to the Cape and back to Cairo, and thence onward to the Solent, which Wing Commander Pulford and his companions have just completed. The fact that the trip was made in the same machines and with the same engines throughout is once again eloquent testimony to the high qualities of British aviation *materiel,* and the successful completion of the flight is no less striking proof of the unrivalled efficiency and spirit of the officers and men of the Royal Air Force. The warmest thanks and the heartiest congratulations of the nation, and indeed of the Empire, are due to Wing Commander Pulford and those associated with him in the flight. The fact that the journey was undertaken by the R.A.F. as a piece of ordinary service routine prevents in some measure the gratitude and appreciation of the public from being shown in the manner that would have been accorded a private effort, but there are recognised means of expressing the thanks of the nation to officers and men of His Majesty's Forces, and there can be no doubt that Wing Commander Pulford's squadron deserves official commendation, even if the flight *is* regarded as "service routine."

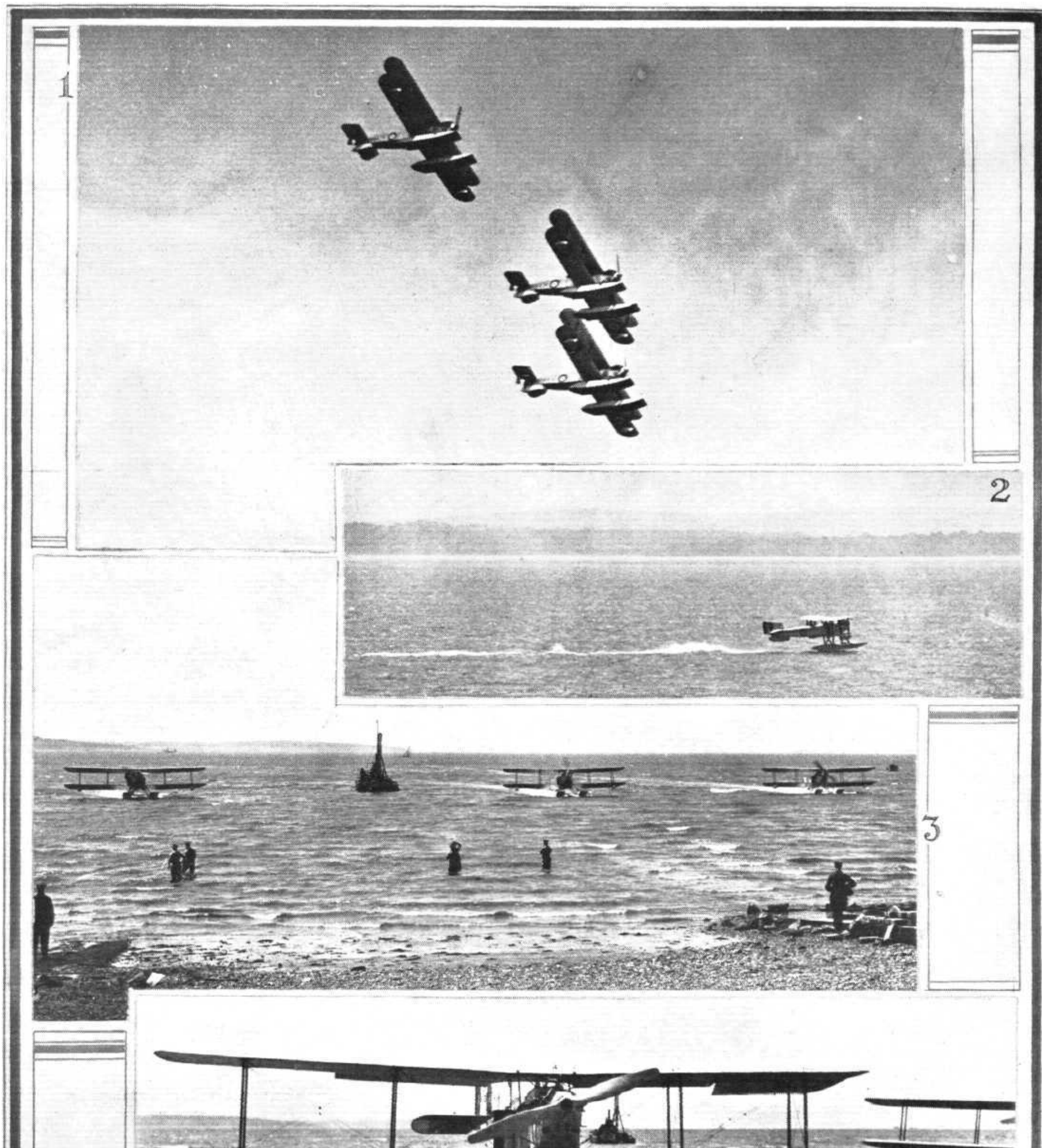
Concerning the flight itself relatively little information is available at the moment. Doubtless, when Wing Commander Pulford has had time to prepare and hand in his official detailed report, something more may be allowed to become known. In the

meantime a few statistics may serve to throw a certain amount of light on the merits of the flight. Leaving Cairo on March 1, Tabora was reached on March 17. During March 18 the flight carried out Army co-operation work with the military at Tabora, and the journey south was continued on March 19, Capetown being reached on April 12. It should be realised that no effort was being made to cover the distance in "record" time, but that the flight was being carried out according to a schedule prepared beforehand. The distance from Cairo to Capetown was 5,289 miles, and the *average* speed was approximately 84 m.p.h. The return journey was commenced on April 19, and Cairo was reached on May 27, the mileage covered up till then being 10,881. The average speed on the homeward journey was approximately 80 m.p.h. Leaving Cairo on May 29 the four machines were flown to Aboukir, there to be fitted with floats for the journey to England. Including the flight from Cairo to Aboukir the four Fairey machines had covered 11,001 miles. But this figure does not include the mileage flown during co-operation with the Army at Tabora. By the time the machines reached Lee-on-Solent they had covered, including the Tabora "show," rather more than 14,000 miles. As there were four machines in the flight this represents some 56,000 "machine-miles." As far as can be gathered from such official information as is available at the moment, there were but two cases during the whole flight when trouble of any sort was experienced. On the outward journey a start was made from Kosti for Malakal, but the machines had to return to Kosti owing to a severe sandstorm. On the homeward journey the flight had left Aswan for Assiut, but one of the machines developed oil trouble and a return to Aswan was made. This appears to be the sum total of the departures from the schedule laid down before the start of the flight. Truly one of the most remarkable performances ever put up by aircraft of any nationality.

Concerning the Fairey IIID machines and their Napier "Lion" engines, it may be said that the former looked "as good as ever" on their arrival at Lee-on-Solent last Monday, and as if, apart from a few touches of dope and varnish here and there, they were perfectly fit to go on another long flight. The engines could not, of course, be inspected in detail, and it is impossible to express any opinion until they have been stripped for examination. From the fact, however, that they have run without complaint for more than 14,000 miles each it is fair to assume that their condition is satisfactory, and the flight has served to demonstrate that water-cooled aero engines will function under tropical conditions when properly looked after. Mr. Cobham's flight to the Cape and back, and the long flight of the Bristol "Bloodhound" between Croydon and Bristol, showed that British air-cooled engines will face the most adverse weather conditions. The R.A.F. Cape flight has proved that British water-cooled engines are quite as "hardy," so that there is cause for satisfaction all round with British aero engines, the prestige of which cannot fail to have been greatly strengthened by such splendid performances.



HOME FROM THE CAPE: Wing-Commander Pulford, O.B.E., A.F.C., p.s.a., receives uniform congratulations from the Navy, Army and Air Force. Shaking hands with Commander Pulford is Captain H. C. Rawlings, D.S.O., a Naval officer attached to the Air Ministry for Air Duties. Looking on smilingly is Air Vice-Marshal Sir Geoffrey Salmond of the Air Council, while behind Sir Geoffrey is Air Vice-Marshal Sir Ivo Vesey, K.B.E., C.B., C.M.G., D.S.O., p.s.c., Director of Organisation and Staff Duties at the Air Ministry. Sir Ivo is wearing major-general's uniform.

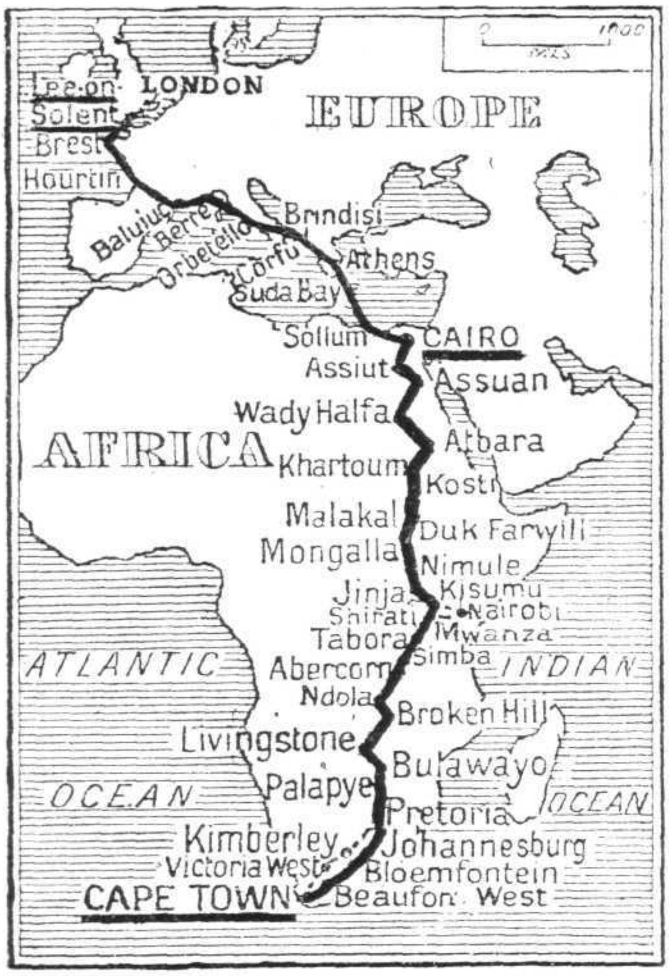


["Flight" Photographs

HOME FROM THE CAPE : Commander Pulford's squadron arrived at Lee-on-Solent on June 21 after having successfully flown from Cairo to the Cape and back, continuing on to England. The total distance covered is approximately 14,000 miles. In 1, are seen three of the four Fairey machines arriving over Lee-on-Solent, while in 2, one of the machines is seen touching "home waters," 3 shows three of the machines taxying up to the beach, while in 4, willing hands are beaching Commander Pulford's machine.

RETURN OF THE CAPE FLIGHT

By MAJOR F. A. de V. ROBERTSON, V.D.



This sketch map of the route is reproduced from the "Daily Telegraph."

Let us honour the names of Wing Commander C. W. H. Pulford, O.B.E., A.F.C., Flight-Lieuts. P. H. Mackworth, D.F.C., E. J. Linton Hope, A.F.C., Flying Officer W. L. Payne, Flight-Lieut. L. E. M. Gillman (navigator), Flying Officer A. A. Jones (technical), Sergeant Hartley (fitter), and Sergeant Gardener (rigger). They have carried out a flight which is unique in many ways and useful in many ways, and they have done credit to the Royal Air Force and to the British Empire. Individual aeroplanes have flown to the Cape and back, to Australia, across the Atlantic, and on many other notable air journeys. Two American army machines have flown round the world. But there has been no other instance on record of a formation of four aeroplanes flying over 14,000 miles, across two continents, from the northern temperate zone to the southern temperate zone and back without change of personnel, of aircraft, or of engines. One would not wish to depreciate the world flight of the United States Douglas aeroplanes, but it is only fair to ourselves to recall that of the machines which started only 50 per cent. reached home, and that all the engines were changed once and individual engines more than once. On this British flight a complete 100 per cent. of the starters returned, not only to the starting point at Cairo but on to England. The only replacements recorded are one magneto and all the oil tanks. The return to Heliopolis was one day ahead of the schedule, despite a few deviations from the selected route. Altogether this flight is a triumph of British organisation and achievement.

While on the subject of organisation, it is only meet, right, and our bounden duty to pay tribute to the ground organisers. The selection of the route from Heliopolis to Mongalla was in charge of Flight-Lieut. S. M. Kinkead; that from Mongalla to Livingstone was prepared by Flight-Lieut. E. C. Emmett, M.C., D.F.C., and that from Livingstone to Capetown was entrusted to Flight-Lieut. W. E. Reason. These three officers have shown themselves to be possessed of exceptional organising capabilities.

On Monday, June 21, we, spectators and correspondents, assembled at the seaplane station of Lee-on-Solent to witness the arrival of the Cape flight. On the previous evening they had reached Brest, some 250 miles distant, and the hour of their homecoming would depend on the weather.

"RECEIVING" THE CAPE FLIERS: Our photograph shows Air Vice-Marshal Sir Geoffrey Salmond congratulating the crews on their magnificent flight. The leader of the flight, Wing-Commander C. W. H. Pulford, O.B.E., A.F.C., p.s.a., is seen standing next to Sir Geoffrey Salmond. The members of the crew are Flight-Lieut. P. H. Mackworth, D.F.C., Flight-Lieut. E. J. L. Hope, A.F.C., Flight-Lieut. L. E. M. Gillman, Flying Officer A. A. Jones, Sergeant Hartley, and Sergeant Gardener

At 9.45 an escort of three Fairey float 'planes from Lee and two " Southampton " boats from Calshot pushed off to meet the African flight. They had not been gone long before they began to wireless that the fog was very heavy off the Needles and they could not pick up the flight there. The " Southamptons " pushed along the coast for some distance, but reported no better luck, so they returned to the Solent and hung about there.

At last a message came through from Brest that the flight had left at 10.00. They found a visibility of not more than 400 yards in any direction, and flew close together about 100 ft. above the water. It was the most trying flight on all their long journey. Though they kept in close star formation, Flying Officer Payne lost the others in the mist, while one of the escorting Faireys also got left behind. Consequently when the whole formation hove in sight about 12.45 the first feeling was one of dismay. There on the two flanks were the " Southamptons." In the centre were three Faireys in a Vic. Behind and up were two more Faireys. Only seven machines where there should be nine. But as a matter of fact there had been no contretemps except the fog. About noon the sky had cleared and the sun broke through and made radiant the whole scene of water, mainland and island. About five miles off the Isle of Wight the Cape flight found good visibility. When Payne got out of the murk he opened up his " Lion " and, flying low, came up in time to land only a few minutes after the other three, and to take his place in line abreast as they taxied to the slipway. The other Fairey from Lee also turned up soon after.

The formation flying of Pulford, Duckworth and Hope was very fine as they passed over the sheds at Lee. Then the two flank machines banked outwards, and all alighted simultaneously in the Solent. The taxying up in line abreast was a very pretty sight. The Wing Commander was the first to come ashore, on the back of a wading airman. Clad in a tropical tunic, which looked as if it might once have been either white or light blue, with badges of rank on the shoulder straps, khaki shorts and stockings, he was tanned to a coppery hue, and looked a picture of physical fitness. All his seven companions looked equally well. They drew up on the beach, and Air Vice-Marshals Sir Geoffrey Salmond and Sir Ivo Vesey shook hands with each officer and airman and Sir Geoffrey, in the name of the R.A.F. and the Air Council, thanked them all for " the splendid success of their enterprise."

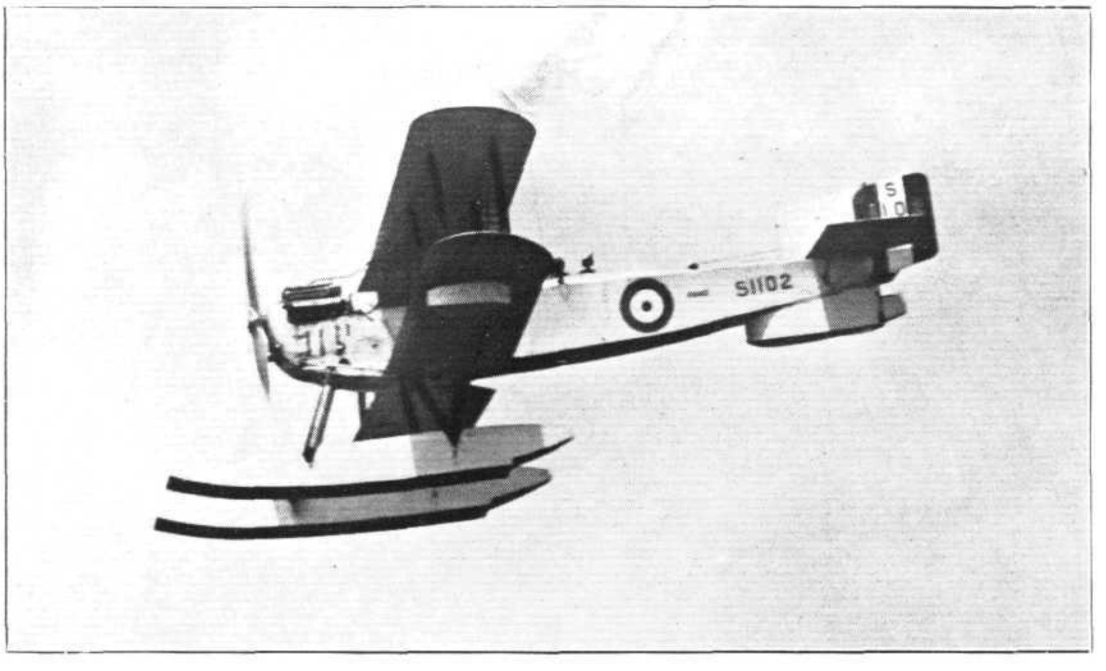
One may give briefly some outline of this great flight. The four machines, as landplanes, left Cairo on March 1. On the 10th they reached Mongalla, where a magneto had to be changed. Tabora was reached on March 17. There the officer commanding the 2nd King's African Rifles, requested a little combined operations, so a day was spent in sham fighting.

Getting in Rhodesia the rarified air on the exalted aerodromes had to be tackled. The " Lions " tackled it all right, and no trouble from that cause has been reported. Pretoria was reached on April 2. They were now in the Union of South Africa. On April 12 the flight reached Capetown on scheduled time.

A week was spent at Capetown, and then the flight returned to Pretoria. At Pretoria the South African Air Force placed their hangars and workshops at the disposal of the flight, and helped in giving machines and engines a thorough overhaul. They were found to be in splendid condition, except for the oil tanks, which showed signs of deterioration from the heat. New copper ones were made locally and installed. They gave complete satisfaction.

Meantime the Governor of Kenya, Sir Edward Grigg, had specially asked that the flight should visit Nairobi, the capital of the Colony. So, leaving Pretoria on May 3, Pulford and his companions pushed on ahead of programme and reached Kisumu on May 11. From Abercorn to Kisumu the weather conditions were bad, but the flight got through. On May 12 they flew to Nairobi and spent three days there, returning to Kisumu on May 15. Then they flew up the Nile Valley and arrived back at Cairo on May 27, one day ahead of time.

This was the official end of the flight; but the Air Ministry wisely decided to summon the party to England. Accordingly, floats were placed on the Faireys at Aboukir, and on June 9 the party started again, reaching Lee-on-Solent on June 21.



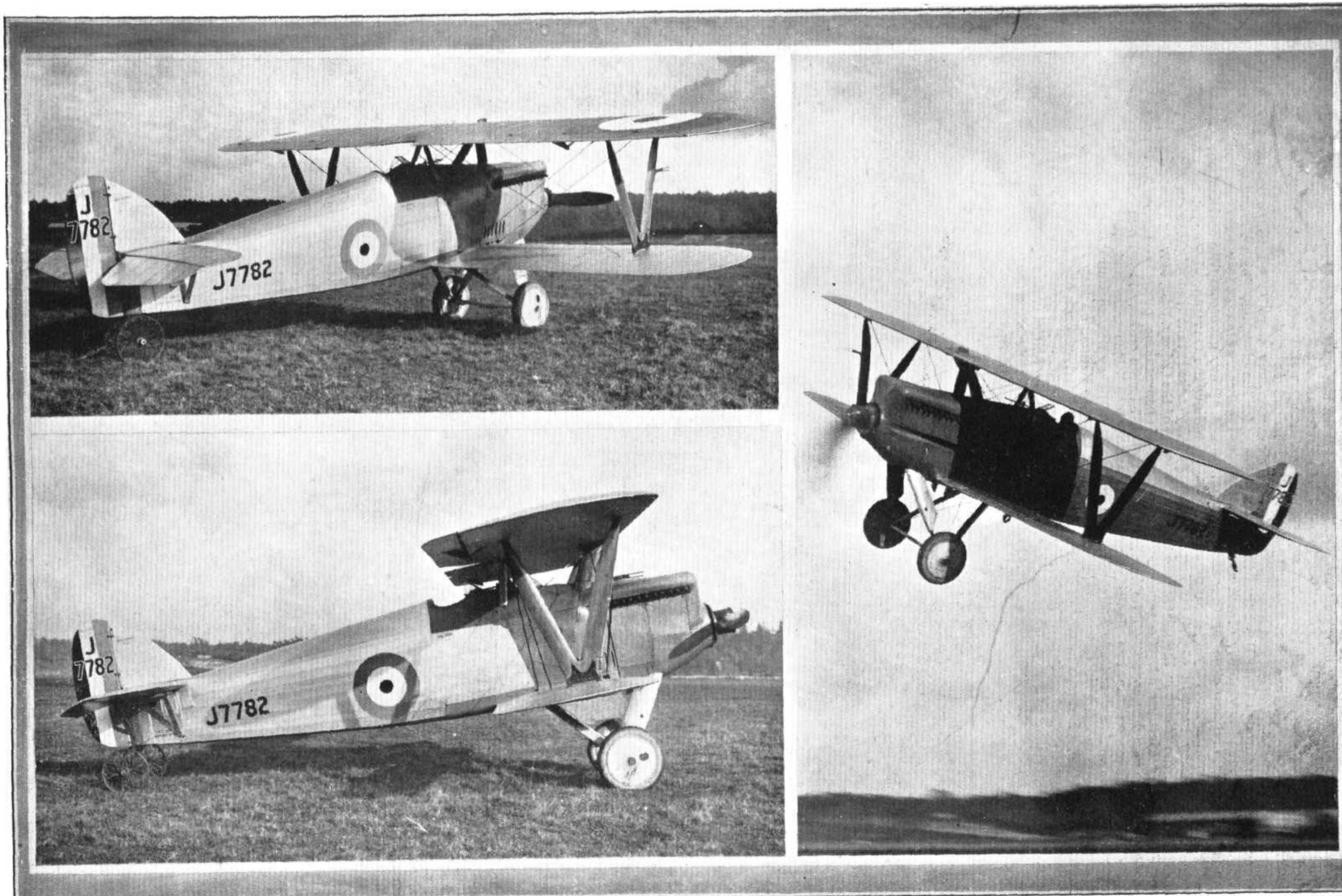
As good as ever: One of the four Fairey machines arriving over Lee-on-Solent. The same Napier "Lion" engines were used throughout the 14,000 miles' flight.

FLIGHT *Photograph.*

Among those present to welcome the four R.A.F. pilots were the following :—Air Vice-Marshal Sir Geoffrey Salmond, representing the Air Council; Air Vice-Marshal Sir Ivo Vesey, Director of Organisation and Staff Duties; Air Commodore E. A. D. Masterman, Officer Commanding No. 10 Group Coastal Area, and Wing Commander E. L. Tomkinson, his chief Staff Officer; Wing Commander C. E. Maude, O.C. School of Naval Co-operation; Wing Commander F. E. T. Hewlett, O.C. Calshot Seaplane Station, and Wing Commander B. L. Huskisson, R.A.F. Base, Gosport. Mr. H. Scott Paine, representing Sir Eric Geddes and Imperial Airways; Mr. C. R. Fairey, and Mr. H. T. Vane, managing director of D. Napier & Son.

The following telegram was sent by Sir Samuel Hoare, Secretary of State for Air, to Wing Commander C. W. H. Pulford, Officer Commanding Royal Air Force Cape Flight :—

" I heartily congratulate you and the personnel of the Cape Flight under your command on their arrival in this country. The successful accomplishment of this flight of 14,000 miles over land and sea without a hitch by four service machines is a most creditable achievement and the regularity with which you have been able throughout to adhere to your time-table is striking testimony of the high standard of training of the Royal Air Force and the reliability of the Fairey machines and Napier engines employed. There could be no more convincing demonstration of the assured future of aviation as a mobile and economical instrument of Imperial Defence and as a reliable means of speeding up communications between this country and the Dominions."



[" FLIGHT " *Photographs*

A HIGH-POWER SINGLE-SEATER FIGHTER: The Hawker "Hornbill," designed and manufactured by the H. G. Hawker Engineering Co., Ltd., is fitted with a Rolls-Royce "Condor" engine. This machine, which will take part in the "Fly-past" at the R.A.F. Display at Hendon on July 3, is of exceptionally clean design, and is very fast.

The AIRCRAFT ENGINEER

FLIGHT ENGINEERING SECTION

Edited by C. M. POULSEN

June 24, 1926

CONTENTS

OUR CONTRIBUTORS

Mr. J. D. North deals this month with a number of different subjects, from that of "tail plane interference" and drag, undercarriage drag, slip-stream effects, etc., to such general subjects as *ad hoc* research and "amateur enthusiasts." His thoughts on ideas for improvement, which "starting soundly enough, are advanced by amateur enthusiasts to extremes outside the intentions of their original sponsors," will certainly be read with interest, although possibly not with complete agreement. Mr. North's advocacy of the slotted wing for racing aircraft is worthy of very serious attention in connection with the Air Ministry's new scheme for high-speed development. Finally, the last passage but one of the present article might usefully be kept in mind: "There is not much probability of making a complete aeroplane with a better lift/drag ratio than the best infinite span wing."

Mr. G. H. Dowty, who is, we understand, connected with the Gloucestershire Aircraft Company, contributes a very useful article on compression rubbers. The type of undercarriage employing rubber blocks working in compression is rapidly gaining favour, and has already proved itself a very useful type, in which simplicity is combined with hard-wearing qualities to quite a surprising extent. Even in the design of such a simple mechanism, however, knowledge is required, and the advice given by Mr. Dowty should be of assistance. It may be recollected that Mr. Dowty has made rather a speciality of undercarriages, and that he read a paper on oleo undercarriages before the Institution of Aeronautical Engineers.

Dr. Leslie Aitchison deals at some length with the subject of the corrosion of Duralumin and its prevention, and the impression formed after reading his article is that Mr. Oswald Short was right when, in the first number of THE AIRCRAFT ENGINEER, he stated that the word "corrosion" has a more fearsome sound than the word "rust," although they are really the same thing, and that while we have come to accept the one as being not very serious, we incline to overrate the importance of the other. With proper precautions there does not seem to be any reason to be unduly alarmed about the corrosion of Duralumin.

AIRCRAFT PERFORMANCE.

By J. D. NORTH, F.R.Ae.S.

(*Continued from page* 55.)

There still remains, apart from those items already enumerated, the *empennage* and the undercarriage as contributories to the total drag. In the case of the fin and rudder these are of symmetrical section normally at Zero lift, except for the effect of race rotation in the slip stream. Omitting the consideration of the latter point, the profile drag coefficient of fin and rudder should not exceed 0·004 to 0·0045 for a braced structure, or 0·006 to 0·008 for an unbraced cantilever arrangement. Similar figures should apply to the *profile drag coefficient* of the tail and elevator. If a braced structure of the usual type (monoplane tail and vertical surface) is used an added drag coefficient of 0·002 to 0·003 will usually cover the external bracing. These surfaces are generally of very low aspect ratio and small in relation to the body on which they are mounted. For this reason plan *form* (as distinct from plan proportions) may have some influence both on profile drag and interference. Profile drag is also affected by the grading off of thickness towards the tips, from which some small advantage is usually to be obtained. It is not difficult to understand that these end effects may influence profile drag on surfaces where the ends are a significant proportion of the span.

Interference on tail planes (often discussed as "tail plane efficiency") has been noticed for many years; careful wind channel work will reduce it to a low figure (or alternatively will give a high "tail plane efficiency").

The actual forces on the tail plane can be determined from the equations of motion. On stable aeroplanes it will be found that over a large part of the flight range a downward force on the tail plane is required for equilibrium. At first sight this would seem very detrimental, as, in addition to the tail plane drag that of the main planes is increased by the lift having to exceed the weight. Actually, however, the tail plane is working in the downwash from the main planes and a regenerative system is formed. A reference to Fig. 14 will show that where the lift/drag ratio of the tail plane is greater than the cotangent of the downwash angle, the component of the tail reaction along the flight path is up-wind. I have not personally seen any analysis which showed an absolute up-wind drag for a tail plane, but the regenerative effect is there to diminish the drag. Examination of several aeroplanes indicates that tail plane drag averages about 5 per cent. of the total drag. Characteristic figures for just stable machines are 6 per cent. on climb, 4 per cent. on top

speed; and for very stable machines, 3 per cent. on climb to 4 per cent. on top speed. These latter figures are only important as showing variations of degrees since many factors enter into the equation of motion which are really beyond the control of the designer who has to make a compromise. Probably the best way to keep tail plane drag down is to keep the lift losses due to body interference as low as possible and so keep down the area of the tail plane.

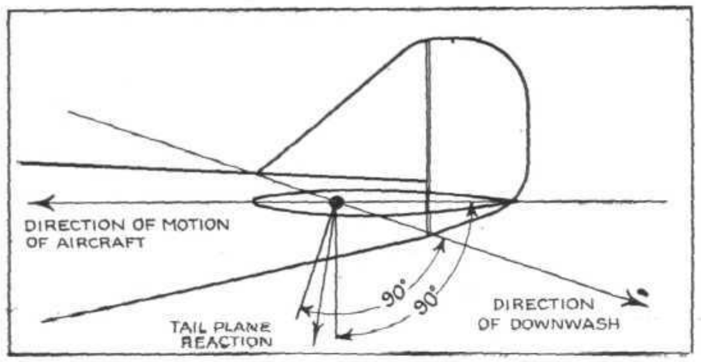


Fig. 14.

The undercarriage offers *per se* little prospect of aerodynamical improvement. The largest items are always the wheels whose frontal area is determined by the permissible bearing pressure on soft ground. The usual figure for this is

$$\text{projected area in square feet} = \frac{W}{1728}.$$

The area is measured as tread by diameter: the resistance of wheels faired is between 4 and 5 lbs., per square foot for small wheels, so that the resistance of the wheel is about $\frac{W}{350}$ lbs./sq. ft. at 100 ft. per second. For larger wheels the figure falls to $\frac{W}{500}$. So far as military aeroplanes are concerned, ground conditions are hardly likely to alter, since these machines may have to operate from unprepared ground. Civil aircraft, particularly on regular routes, might be made more independent of ground conditions if engine reliability can be maintained at a very high figure. The possibility of specially surfaced aerodromes or launching gears is not very near. Attempts at disappearing undercarriages are unsound mechanically, and probably give rise to more resistance in attempting to provide accommodation of the undercarriage than they save. I do not believe any aeronautical engineer regards such a scheme seriously. Wheels are not only the most important items of undercarriage resistance in themselves, but they are particularly liable to give rise to interference resistances with the chassis struts. Wind channel tests show that these interferences may be avoided, but as with most other interference phenomena, these tests are largely a matter of trial and error. As an interesting example of what wheels can do I may instance the analysis of the resistance of a racing car carried out in the Boulton & Paul channel, which showed that the front wheels and their interference with the body were the biggest items of resistance.

It is difficult to divide the various factors which go to determine the performance of an aeroplane into water-tight compartments—they are all more or less mutually dependent. I propose, however, to treat the propeller and engine together, as the power plant, since so many of the propeller characteristics are really determined by the engine. In this section of these notes I will, therefore, make only a brief mention of slip-stream effects. The flow through a propeller is streamline, *i.e.*, total head is constant, hence the inflowing stream contracts in front of the propeller and the outflowing stream contracts behind it as the stream velocity increases; this is shown diagrammatically in Fig. 15.

This streamline flow is liable to interference. In multi-engined machines interference in the inflowing stream may obviously take place even where the propeller diameters do not overlap in front elevation. Similar interference may take place between the body and inflowing stream, particularly if the body projects far forward of the propeller disc, has a poor entry and small clearance. These interference phenomena are common knowledge and experience on machines of quite recent design, and it is sufficient to point out that clearance in front elevation is not the true criterion. Experimental work in the wind channel on arrangements designed from carefully plotted streamlines will ensure freedom from interference. Judging from personal experience on these lines I would express as my opinion that all three-engined aeroplanes, of which drawings have been published in technical papers to which I have access, have some measure of propeller stream interference, not always enough to cause vibration, but sufficient to affect performance, particularly at low speeds. It is always possible to be wrong in expressing an opinion on interference, but I give this opinion with fair confidence.

The outflowing stream has a rotary component varying with intensity at different radii, and, of course, at various values of $\frac{V}{nD}\left(\frac{\text{linear speed}}{\text{angular speed} \times \text{diameter}}\right)$. The effect of this obliquity of the slip stream is well known as disturbing the symmetry of an aeroplane and causing a yaw when the rudder is left free. This obliquity must also affect the resistance of bodies in the stream, but so complete is the flow that it is difficult to allow for in design. It is probably better to aim for stability of flow, *i.e.*, small change of drag with incidence, than attempt to adjust the attitude of the parts likely to be affected. There is another pitfall for the designer, whose only safeguard can be wind-channel work on a large and representative scale. The general effect of the slip stream as affecting resistance by increase of air velocity I prefer to discuss under power plant and propeller efficiency, since it is in the power plant balance sheet that the drag from this cause should properly appear.

The reader will have gathered that I do not see open any way to substantial aerodynamic improvement, over best practice in the aeroplane proper. It is, however, only too easy to fail to achieve what theory and practice tell us can be, and ought to be, possible. If the specification of an aeroplane is simple, *e.g.*, if merely carrying a man or so is its sole requirement, design is fairly easy; aerodynamical considerations can be put first, as they were in the aeroplanes of ten years ago, but aeroplanes are now highly specialised machines, particularly those intended for military purposes. Numerous cockpit openings, large bodies to accommodate equipment and allow free movement to the crew, the provision of awkward angles for view and gunfire, all decrease not only the aerodynamic efficiency that *can* be attained, but decrease to a far greater degree *the probability that that best will be obtained.*

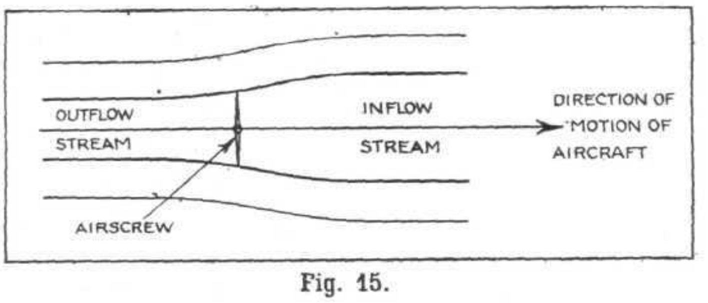


Fig. 15.

There is, outside the ranks of professional engineers, a complete misunderstanding of engineering work. Nowhere is this misunderstanding greater than in the aeronautical world. Some imagine that all the data necessary for design is provided by the work of national research establishments, whereas in fact, such is the barest skeleton and scarcely touches the real problems which make for successful design. It is difficult to see how it can be otherwise. Scientific research is a map on a very small scale and endeavours to cover a very large country and to open up fresh territory. Engineering design is cartography on a very large scale, so large in fact as to miss no feature large enough to affect the desired result. A mining prospector, whose sole equipment is a small-scale geological survey of the continent of America, is not likely to discover an El Dorado.

Theory is like a map—it helps you to get near your goa but finally you must depend on "local" knowledge. Local knowledge, on the other hand, is of little value away from its own locality. We have heard a great deal about "unorientated" and "ad hoc" research. The former term is, I think, unfortunate, being too nearly a Latinised form of "aimless,"

which this class of research too easily becomes. I suppose a certain number of geniuses, wandering "aimlessly" as the spirit moves them, are always worth while, always liable to make some great discovery, but lesser men may unfortunately use this excuse as an easy escape from the trying discipline of systematic work. If it is necessary to excuse misdirected work, particularly scientific work, as "interesting," this term is really only a euphemism for "harmless." Indeed, since human resources are limited, it may easily be harmful as displacing more definitely needed experiments. The specialised data at the disposal of the aeronautical engineer is very varied. The amount he can apply directly to his work is very limited. The work of separating the wheat from the chaff is very laborious—in fact outside the power of the industry individually as it stands to-day. In consequence the engineer is very chary of allowing the success or failure of his work to depend on data he has not verified to the best of his abilities. The merits of a thesis are open to dispute or argument, the merits of a design are largely put to the proof of practice, and the greater the departure from immediate experience the greater the possibility of failure. Perhaps this is why it is sometimes cynically observed that aeronautical research and design proceed on parallel lines—they never come into contact.

On the other hand the aeronautical world is particularly susceptible to ideas for improvement which have no sound scientific basis, or which, starting soundly enough, are advanced by amateur enthusiasts to extremes outside the intention of their original sponsors.

The first class are hardly suitable for technical discussion; a single example must suffice, that hardy annual of twenty years standing, the giant aeroplane. From some obscure analogy has grown up, and persisted, the idea that long distances—the Atlantic Ocean in particular—can be traversed economically and securely in an aeroplane, if only it is large enough. It has been repeatedly pointed out that dimensional theory indicates that long distance travel is *more* difficult after an aeroplane passes a very moderate size, and that a very fair estimate can be given of the size of the aeroplane which, built on normal lines, could not lift its own weight. Of the latter class it is worth while to examine the examples of :—

(1) The cantilever (thick) wing.
(2) The light aeroplane as the type of the real commercial aeroplane.
(3) The slotted wing.
(4) Very high loading.

(1) The appeal of the *cantilever wing* is not difficult to understand. There is a specious air of cleanness about the design which might easily deceive an amateur without quantitative evidence at his command, into believing that a notable advance in aeroplane design, if not a universal panacea for aeronautical ills, was to hand. A good many professional engineers (mostly Continental) were stampeded in the same direction. Very exaggerated performance claims were put forward, not substantiated by reliable testing. The cantilever and the thick wing can be investigated by modern aerofoil theory, and except in special cases, the advantage goes to the biplane. There are circumstances where this construction gives advantageous general arrangement, but it would be more correct to say that the advantage is incidental and not intrinsic. The study of wings suitable for this type of construction was actively pursued during the time when the "cantilever" school was in the ascendant. It is instructive to re-examine some of this work in the light of modern aerofoil theory. I have already mentioned that the load distribution along the span of a tapered wing can be calculated from the vortex theory and that the difference of distribution between tapered and rectangular wings is much less than would be imagined from strip theory. The instructive point is the examination of tests and results on wings of various thicknesses. I select for this purpose the very full series published in the N.A.C.A. Report No. 75 (1919). The method of attack was that usual at the time, but the results and conclusion can be re-examined in the light of modern theory. Firstly, a graduated series of "affine" sections was chosen, formed by varying the ratio of the scales of the horizontal and vertical ordinates. Those who have read the previous instalments of these notes will at once recognise that these sections are not "affine" at all so far as their probable characteristics are concerned, since by thickening the section in this way the centre line curvature has been increased. It is not surprising that thickest sections are very inefficient and become unstable, *not* because they are thick but because of the heavy centre line camber. Further experiments thickening the wing by convexing the under surface, gave efficient aerofoils, in fact aerofoils of the type which would have been obtained if the centre line curvature had been kept constant when the aerofoil was thickened. The importance of thinking of centre line curvature and of the chord as the chord of the centre line are emphasised in such comparative tests. Series of wing sections of the type first described may be used with certain advantages, constructional and aerodynamical, but the curvature of the thickest wing should be kept down to the safe limit, *e.g.*, camber, 0·05.

(2) After the success on the Continent and in this country of gliding and soaring flights in 1921-2, and the subsequent development of the *light aeroplane* of the types of the Lympne meetings of 1924 and 1925, commercial aeroplanes were adversely compared with these light machines, and it was even suggested that designers of commercial aeroplanes had here a definite example of how to make their aeroplanes more efficient.

What are the facts? Firstly the $\frac{\text{Span}^2}{\text{W}}$ ratio of these small machines was 1 to 1·5 as compared with 0·3 to 0·5 for the average aeroplane. The values of induced drag at low indicated air speeds (50 to 60 m.p.h.) were in consequence small. At these low indicated speeds the drag of the primitive bodies and undercarriages was small. The propellers were working at reasonable values of $\frac{\text{V}}{\text{n.D.}}$ and $\frac{\text{D}^2}{\text{H.P.}}$, although at high absolute r.p.m. The engines were small in relation to the body, and of low drag because of low power. All these factors react on one another. These methods of design were admirable for the purpose of this type of aeroplane, but to apply them to a commercial aeroplane, say 9 to 16 times the weight, is another matter. To keep the same span²/weight ratio, a D.H. 34 would have to be about 110 feet span and a W.8 about 150 feet span. The structure weight would rise enormously (theory indicates something in the neighbourhood of 70 per cent.) far outweighing the advantage gained by reducing fuel and engine weight. The operational speed would, however, be only 60 to 75 miles per hour, not sufficient for European services. Increase of engine power to raise this speed means more drag and lower propeller efficiency unless the r.p.m. are progressively lowered. As operational I.A.S. increases $\frac{\text{Span}^2}{\text{W}}$ may come down; in fact, *must* come down if any useful load is to be carried, and continuance of these steps to their logical conclusion brings one to something very like the present-day commercial aeroplane. The point is that the small aeroplane had special features by reason of dimensional effect on the structure. To suggest that the logical result of these effects should be applied to larger aeroplanes is as if one eulogised the simplicity of a plank over a stream and advocated its adoption on a large scale as a suitable structure for the Forth Bridge.

(3) The case of the *slotted wing* is very important. It is, I think, true to say that this is the only real aerodynamical discovery of the last decade, and was undoubtedly a brilliant invention. Unfortunately, although the inventors have been very careful to present its features moderately and reasonably, the most ridiculous claims on its behalf were made by others. The aeroplane as an economical vehicle was to improve beyond recognition; yet in spite of this a slotted aeroplane is a true *rara avis* today. Why is this? The answer is, I believe, that with accepted landing speeds and economical $\frac{\text{span}^2}{\text{weight}}$ ratios, the slot cannot improve performance. It has already been explained that this and similar devices can only be used for *decreasing the chord*, and if the $\frac{\text{thickness}}{\text{chord}}$

ratio has to be increased in consequence the gain in profile drag is soon swallowed up. If anything of advantage remains there is the added weight and cost to be set off against it. If one thinks of slots in these terms, one sees the limitations of this nevertheless important discovery. The flap, except in conjunction with the slot, is merely a very old and inferior way of obtaining results of the same type, but to a much smaller degree. I believe the old trailing flap (not, of course the control organ) is dying, if not dead.

It is surprising that racing aeroplanes, in which the slot should be most valuable, have not made use of this device. Whatever the reason may be, I think I am correct in saying that the highest performance aeroplanes today do not make use of any such device.

(4) *Very High Loading.*—This is really the slotted aeroplane without the slot. There again variations of loading ought logically to be made only by varying the *chord*. If $\frac{\text{span}^2}{\text{weight}}$ is kept too low in conjunction with high loading, difficulty in getting off is experienced. The extremes of high loading are preached by Dr. Rohrbach, who put forward his arguments to this effect in his paper before the Royal Aeronautical Society. Some of his arguments are, on the face of them, plausible, and his machine has been ingeniously selected to show his theories at their best. A careful re-reading of his paper has left me with the feeling that the principal advantage which Dr. Rohrbach finds in ultra-high loading is that without it he could not use his system of construction.

Where, then, is the aeroplane designer to look for improvement? I repeat, that so far as we can see, the aeroplane itself offers little hope for aerodynamic improvement. Concentration is required on getting the best combination and tempering specification requirements with an understanding of what they involve. Mr. Gnosspelius, I believe it was, who asked why an aeroplane would not run down a slope of one in a hundred if a train could. This is really similar to asking why a man cannot swim as fast as he can run. There is not much probability of making a complete aeroplane with a better lift-drag ratio than the best infinite span wing.

There are, however, other factors which go to make the performance of an aeroplane—namely, the power plant and the structure—and to these we may next turn our attention.

(To be continued.)

COMPRESSION RUBBERS.

By G. H. DOWTY, A.F.R.Ae.S., A.M.I.Ae.E.

Whereas there is much published data on tension rubbers there is comparatively little information available on the properties of compression rubbers. It is curious that rubber manufacturers publish little, if any, information on the properties of their rubbers, and it is generally left to the aircraft makers to obtain rubbers and carry out their own mechanical tests. This article gives the summarised results of many tests on various types of compression rubbers. The conclusions reached regarding the suitability of any one type are based directly on the results of these tests. While it may appear that the formulæ are obtained by generalising from particular cases, yet, from many tests, it appears that the difference in characteristics of compression rubbers of similar design is not so great that a general conclusion cannot be drawn.

As a means of aircraft springing, compression rubbers have to a large extent superseded tension rubbers. The chief reasons for this change are :—

(1) Compression rubber is more durable and keeps its elastic properties longer than tension rubber.

(2) Compression rubber has a larger hysteresis value, and the tendency for an aeroplane to bounce on landing is less pronounced than in the case of a tension rubber undercarriage.

(3) Compression rubbers are easier to fit and replace than tension rubber rings or cord.

(4) Compression rubber can be stored indefinitely without deterioration.

Compression rubbers have been extensively used on railway coaches and wagons as a means of springing and for buffer drawgears. An example of two railway rubbers is shown in Fig. 1, where the proportions and deflections under maximum load are tabulated. These particulars show that 50 per cent. compression is developed under stresses of 730 and 780 lbs. per square inch. From these readings it appears that the rubbers are somewhat similar as regards deflections to the Parnall type rubber shown on curve 3, Fig. 3. The makers of this railway rubber are Spencer, Moulton & Co., Ltd. They guarantee that these rubbers will stand all weather conditions and retain their elastic properties up to the loading stated. It is of interest that railway compression rubbers are designed with a view to a life of over 15 years. This fact serves to show the durability of compression rubber, although on aircraft where rubbers are called upon to meet wide changes of temperature and subject to higher loading it is never anticipated that the life of the rubbers will be more than two years.

There are several types of compression rubber in use, and three forms are shown in Figs. 2, 3 and 4.

Fig. 2 shows the simplest form, consisting of a plain ring.

George Parnall & Co. were the first aircraft firm to adopt compression rubbers as an alternative to tension rubbers, and the Parnall type of rubber with moulded-in stabilising plate is shown in Fig. 3.

One disadvantage noticeable with a compression rubber undercarriage leg is that generally the width is greater than would be the case if tension rubbers were used. The type of rubber patented by The Gloucestershire Aircraft Co., and illustrated in Fig. 4, has been designed to obviate the necessity of a wider leg and also produce a rubber that would lend itself to good streamlining.

I am indebted to The Gloucestershire Aircraft Co. and Geo. Parnall & Co. for permission to illustrate and describe their rubbers.

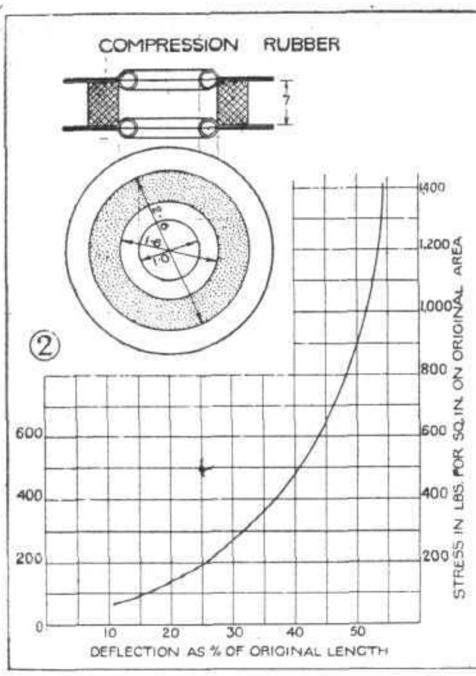
It is essential to stabilise compression rubbers to prevent the column bowing under load, for this would set up uneven loading on the rubbers and the eccentricity would possibly cause collapse of the leg. A further requirement is the addition of separator plates between each rubber. This is necessary to enable the rubbers to spread easily under load so that reasonable deflections may be obtained without the use of an undue length of rubber.

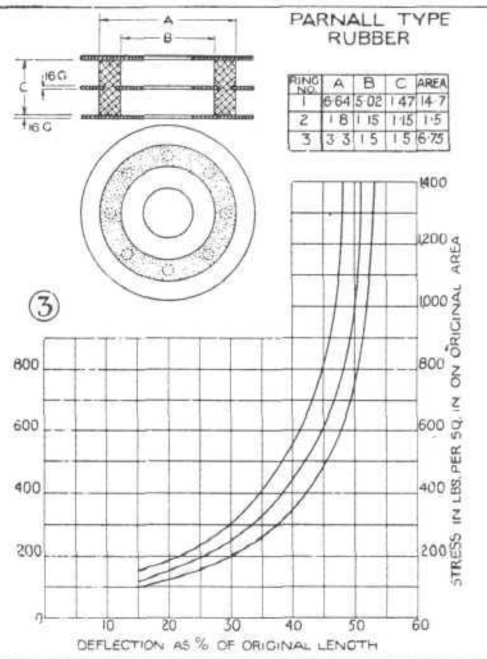
In the case of the ring shown in Fig. 2 the stabilising and separator plates are integral. The plates are made from a light gauge aluminium plate pressing similar in design to that shown in Fig. 5. Two such plates placed back to back are placed between each ring. Another method is to allow the inside diameter of the rubber to be only slightly larger than the diameter of the guide rod. In this case no provision for stabilising is required and the separator plates consist of a plain metal disc with a central hole large enough to accommodate the guide rod. This method is not so desirable inasmuch as it does not make provision for the spread of the rubber inwards and consequently the rubber will bind on the guide rod and a more stubborn springing will result.

For the type of rubber illustrated in Fig. 4 the stabilising is carried out by the internal surfaces of the rubber coming in point contact with the guide tubes and main leg member. This method of stabilising is indicated in the plan view of Fig. 4. The usual separator plates are employed and the rubbers are covered with graphite powder to provide lubrication of the surface and facilitate spreading.

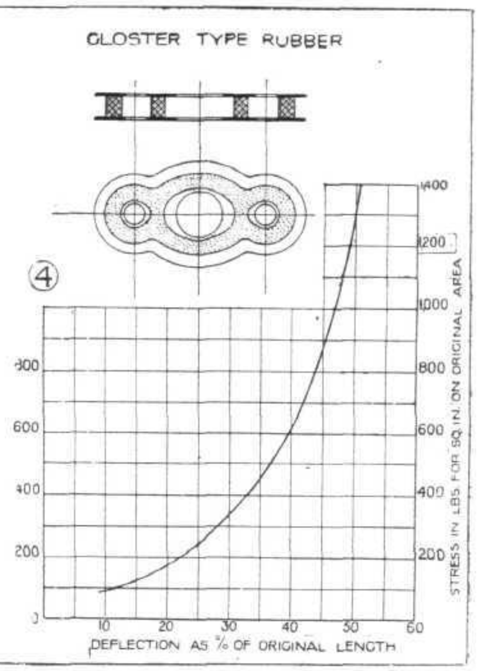
It has been found that the stress on aircraft compression rubbers under static load should not exceed 250 lbs. per square inch, otherwise the rubber will be harsh in operation during taxi-ing and will quickly take up a permanent set under load, losing an appreciable portion of its elastic properties.

Perhaps the most useful data for determining the necessary particulars of a compression rubber shock absorber is the stress deflection graph. Such graphs are given in Figs. 2, 3 and 4. The use of the graphs will be best shown by working out an example.

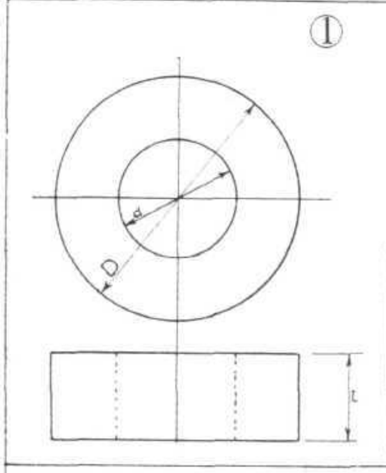




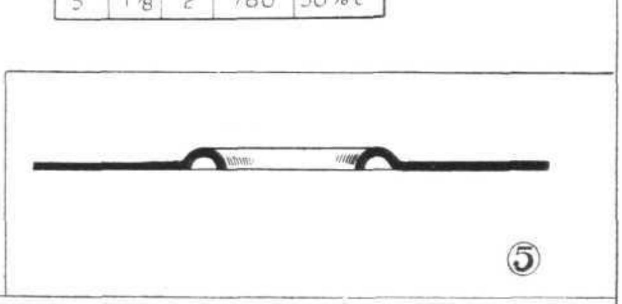
RING NO.	A	B	C	AREA
1	6·64	5·02	1·47	14·7
2	1·8	1·15	1·15	1·5
3	3·3	1·5	1·5	6·75

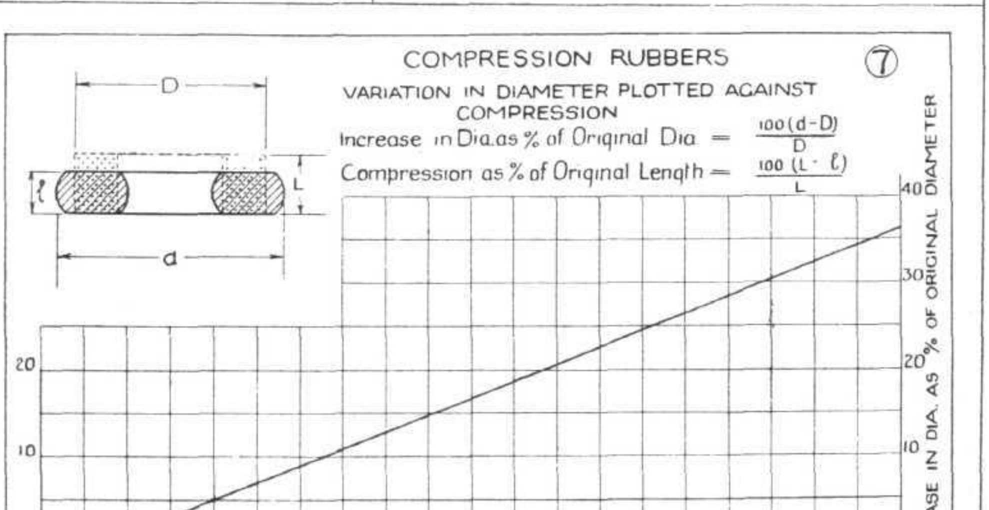


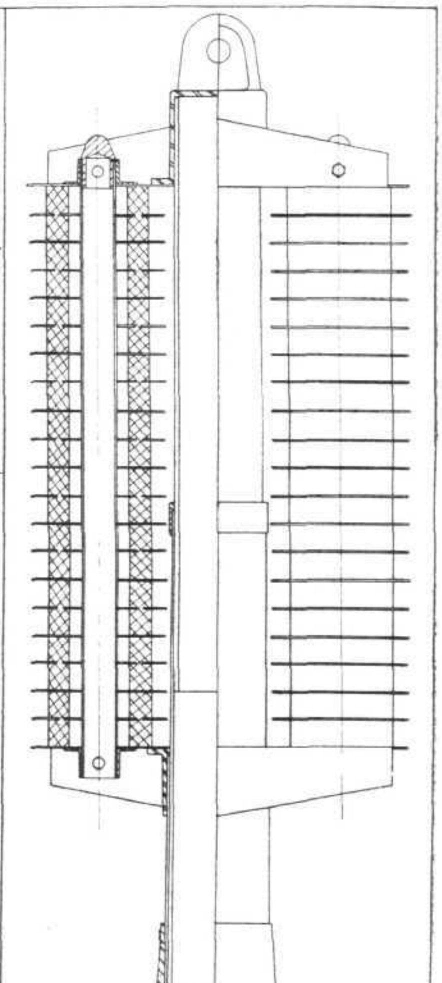
COMPRESSION RUBBERS: Three types are shown in Figs. 2, 3, and 4. Of these the one represented in Fig. 2 is the simplest form, consisting of a plain ring. The Parnall and Gloster types are shown in 3 and 4, and stress-deflection graphs are given for all three types.



D	d	t	STRESS LBS/IN²	COMPRESSION
4¼"	1½"	1½	730	50% t
5"	1⅞"	2	780	50% t







COMPRESSION RUBBERS: An example of two railway rubbers, made by Spencer, Moulton & Co., is shown in Fig. 1. From the readings it appears that these rubbers are somewhat similar, as regards deflections, to the Parnall type shown in Fig. 3. It is of interest to note that railway compression rubbers are designed with a view to a life of over 15 years The separator plates of the type of rubber shown in 2 are similar to that illustrated in 5, two being placed back-to-back. A typical compression rubber "leg" is illustrated in Fig. 6, while Fig. 7 contains the information for determining the increase of the diameter of the ring when subject to its maximum compression.

Determination of Rubber Area and Length of Rubber Column.
Where :—

w = static load on rubbers in lbs.
W = maximum load on rubbers in lbs.
T = required deflection of column in ins. under W.
A = cross-section area rubbers in sq. ins.
l = length of column in ins.

The first three values, w, W and T, are always known before the design of the shock absorbing member is commenced.

By way of an example let :—

w = 2,000 lbs.
W = 10,000 lbs.
T = 7 ins.

The maximum permissible stress on the rubber under static load as stated previously is 250 lbs. per sq. in.

$$\text{Therefore } A = \frac{2{,}000}{250} = 8 \text{ sq. ins.}$$

and the stress on the rubber under maximum loading is

$$\frac{10{,}000}{8} = 1{,}250 \text{ lbs. per sq. in.}$$

Assuming that the type of rubber used is similar to that shown in Fig. 2, then from the stress deflection graph it is seen that this stress corresponds to a deflection of 53·5 per cent.

As the total deflection is 7 ins. then

53·5 per cent. l = 7 ins.
i.e., l = 13·1 ins.

The following formulæ, derived from the stress-deflection graphs, will be found useful as an alternative method for determining any one of the four unknown quantities when the other three are given :—

δ = deflection of column in inches.
l = length of rubber column in inches.
A = cross-section area rubber in sq. ins.
L = load on column in lbs.

For plain type ring, as shown in Fig. 2.

$$\delta = l\left(0{\cdot}615 - \frac{104\,A}{L}\right) \qquad \text{(I)}$$

For Parnall type, Fig. 3.

Curve 1.

$$\delta = l\left(0{\cdot}544 - \frac{76\,A}{L}\right) \qquad \text{(II)}$$

Curve 2.

$$\delta = l\left(0{\cdot}58 - \frac{81{\cdot}5\,A}{L}\right) \qquad \text{(III)}$$

Curve 3.

$$\delta = l\left(0{\cdot}59 - \frac{70\,A}{L}\right) \qquad \text{(IV)}$$

For "Gloster" type, Fig. 4.

$$\delta = l\left(0{\cdot}56 - \frac{95{\cdot}5\,A}{L}\right) \qquad \text{(V)}$$

These formulæ cease to hold good below deflections of 35 per cent.

To illustrate the use of the above formulæ : Take the case of the example previously considered where

$$\delta = 7 \text{ ins.}$$
$$A = 8 \text{ ins. sq.}$$
$$L = 10{,}000 \text{ lbs.}$$

Rubbers of the same type (*i.e.*, as Fig. 2). From formula I.

$$7 \text{ ins.} = l\left(0{\cdot}615 - \frac{104 \times 8}{10{,}000}\right)$$
$$= 0{\cdot}5318\,l$$
$$\therefore\ l = 13{\cdot}2 \text{ ins.}$$

This agrees to within 1 per cent. of the length previously calculated.

It must be understood that the stress-deflection graphs given for the various types of rubbers only apply to rubbers geometrically similar. If the proportions of the inside and outside diameters to the thickness remain the same, then as far as present tests indicate, the stress-deflection graph remains unaltered with increase of cross-section area.

In order that the outside diameter of the stabilising and separator plates may be determined, it is necessary to know the increase of the diameter of the ring when subject to its maximum compression. This information is contained in Fig. 7.

Where

y = increase of diameter as per cent. of original diameter.
t = deflection as per cent. of original length.
$y = 0{\cdot}782\,(t - 4)$.

The most advantageous form of compression rubber depends entirely on the type of machine for which it is required. For high-speed aircraft, where a reduction of frontal area is of primary importance, the "Gloster" type of rubber is undoubtedly the best form and lends itself to good streamlining. In the case of slower speed aircraft and especially of the commercial type, where accessibility, ease of replacement and initial cost are governing factors, then the ring type of compression rubber shows advantages.

In designing rubbers, the proportioning of the rubber is the all-important point, for it is essential that the mass should be disposed in its most favourable position for spreading. In the several illustrations of rubbers, proportions are given which are known to be good, but it is not suggested that these proportions are ideal because further investigation is necessary, and this work should be done by the rubber manufacturer. The necessity of good proportioning is brought out by the following illustration. If two rubbers of the same type, quality and cross-section area, but of different proportions, are tested and under equal loading the one gives 50 per cent. and the other 40 per cent. deflection, then by using the former rubber there would be a saving of 20 per cent. in weight over the latter plus a reduction of 20 per cent. in the length of the rubber column. This represents a considerable saving, both in weight and frontal area.

A typical compression rubber leg showing the arrangement of the various components is illustrated in Fig. 6.

In this article no attempt has been made to discuss the shock-absorbing qualities of compression rubber. Generally, some form of oleo gear is incorporated in the leg, which absorbs the major part of the energy due to the vertical velocity of the aircraft. With this arrangement the compression rubbers are used as a means of spring suspension only.

DURALUMIN

By LESLIE AITCHISON, D.Met., B.Sc., F.I.C., M.I.A.E.

(*Continued from page* 56.)

The corrosion of Duralumin may profitably be considered under three headings : Firstly, the evidences of corrosion ; secondly, the ways in which the corrosion may be accelerated ; and, thirdly, the methods which may suitably be employed for the prevention of its occurrence. The corrosion which does occur on Duralumin shows its presence by the formation of a white, somewhat powdery, deposit on the surface of the metal. The distribution of the corrosion over the surface of Duralumin is approximately similar to that of the rust that forms on steel in the early stages of an attack. It is unusual for the surface of attacked Duralumin to become covered with a uniform film of corrosion products such as occurs on steel. The products of corrosion gather in spots, and unless the corrosion has gone on for a very considerable time the surface of the metal never becomes even approximately wholly covered. As a result of this method of attack, such corrosion as occurs tends to spread into the metal by the formation of pits and not by an attack on the whole of the surface of the metal.

The rate at which Duralumin suffers corrosion is not high, and a comparatively small amount of corrosive reaction results in the formation of a very noticeable quantity of corrosion product. The presence of this corrosion product can be detected very readily, and if the metal is cleaned as soon as

the attack is observed no particular harm will be done, except that the surface of the metal will have been slightly pitted and roughened. If the surface corrosion is not removed, then the attack may proceed to some depth into the material, and at certain pits may progress to a comparatively considerable depth without giving any marked evidence of its increase (by the formation of surface deposits of corrosion products). The further corrosion of the metal may take place by the enlargement of the surface pits, in which case the depth of any one pit may not be very great. On the other hand, the attack may be concentrated in a direction at right angles to the exposed surface of the metal, thereby producing a few relatively deep pits. Furthermore, the corrosion may proceed along the crystal boundaries, and thereby affect the metal for quite a considerable distance without producing any intense quantity of the tell-tale white surface deposit. In this last case it is quite possible to clean the surface of the material entirely from the corrosion product, and also to remove the obvious pits without removing entirely the metal which has been affected by the corrosive attack. Cleaning the surface of the metal removes the greater part of the corrosion and also removes the seat of the reaction. It thereby causes the corrosion to come to an end. It does not necessarily, however, remove all the Duralumin which has been affected by the corrosion and such metal may suffer considerably from the presence of internal lesions.

Such material is usually weak and relatively brittle, and is thereby very readily detected. All the evidence goes to show that the formation of this type of corrosion is the result of a prolonged exposure to corrosive influences, and there is no evidence at all to indicate that the material develops an intercrystalline type of corrosion, or any severe attack at right angles to the surface, except when it has been exposed for a lengthy period to conditions that actively promote corrosion.

It has been suggested that the corrosion of Duralumin may go on inside the material without any apparent attack on the surface. There is no evidence whatever that this opinion is correct, and there is multitudinous evidence to the contrary. Corrosion takes place from the surface of the metal, and, therefore, if the surface is protected against attack, the material throughout will be free from the effects of corrosion. If the corrosive agents are kept away from the surface, there can be no question whatever about corrosion occurring in the metal. It simply does not take place. What may occur is that on metal which is not protected on the surface the corrosive action may be confined to a relatively small number of surface pits, which allow the metal to be attacked at right angles to the surface, and not parallel to it, thereby producing an apparently large effect within the body of the metal, whilst giving comparatively small evidence of the existence of the attack on the surface of the metal.

Duralumin which has been left undisturbed during the process of corrosive attack will always show upon its surface evidence of any corrosion that has occurred, and in the absence of such surface evidence it is entirely safe to assume that the interior of the metal is free from the effects of corrosion. If, however, the material has been allowed to corrode and then been cleaned, the evidences of corrosion may have been removed without the whole of the effects having been eliminated. It is for this reason that it is desirable to take precautions to avoid the occurrence of any corrosion over a lengthy period. As has been stated above, Duralumin does not corrode readily. It resists corrosion far more than steel does, and is much less attacked than the ordinary yellow metals. It is either from prolonged exposure to ordinary corrosive influences, such as saline solutions, or from shorter attacks by exceedingly violent re-agents, that a serious attack is likely to be met. It is foolish, however, to believe that Duralumin is entirely immune from corrosion. Its resistance to corrosion is certainly great, but by no means so great that the possibility of an attack can be overlooked, and it is decidedly desirable to protect the surface of the material at all times after manufacture so as to minimise the possibility of the production of pitting in such a form as cannot readily be removed when once it has taken place.

With regard to the ways in which the corrosion of Duralumin may be accelerated, it appears only necessary to indicate those circumstances which tend to produce this result. The actual conditions to which Duralumin may be exposed in aeronautical work are sufficiently well-known to make it unnecessary to detail their effects separately. Provided that it is recognised that saline solutions, of which the most typical is sea water, exercise a corrosive influence upon Duralumin similar in effect to, but smaller in magnitude than, that produced upon ordinary iron and steel, little further need be said respecting the agents which actually produce the undesirable effects. Duralumin in all its different conditions does not, however, resist corrosion with the same facility. The most resistant form of Duralumin is the normal metal, that is the material that has been heat-treated and fully aged. Duralumin that has been annealed is not so resistant to corrosion by a long way, and it is decidedly desirable not to use the metal in the annealed condition when it is likely to be exposed to severely corrosive influences. Duralumin which has been cold-worked after heat-treatment is very nearly as resistant to corrosion as is the normal metal, and it is far and away better in this respect than the annealed metal. The difference between the normal and the cold-worked material is comparatively small, but the difference between annealed and heat-treated Duralumin is sufficient to make it possible to induce galvanic effects by placing metal in these two conditions together.

A further incentive to accelerated corrosion is produced by putting Duralumin in contact with other metals, and particularly the yellow metals. When copper or brass or bronze is in close contact with Duralumin, and the combination is exposed to corrosive influences, the Duralumin is affected adversely. Of course, the two metals may be placed in contact and then protected adequately against corrosive influences. In such a case no detrimental result will follow. On the other hand, if steel and Duralumin are placed together corrosion occurs at a definitely accelerated rate but in this instance the more affected materal is usually the steel.

Whilst discussing those points which affect the corrosion of Duralumin it may not be out of place to mention that dilute salt solutions are more active in their effect than concentrated ones. If sodium chloride be taken as a typical salt solution it is found that the greatest attack takes place at a concentration of salt very much lower than that present in sea water. With a concentration about one-sixth as great as that present in sea water common salt solutions attack Duralumin the most intensely. It is desirable that this point should be borne in mind, particularly when the method of removing salt, *e.g.*, from salt baths, is in question, and also when Duralumin may be exposed to an atmosphere that is essentially wet, and at the same time liable to be contaminated with salt spray.

The third question is that of the methods to be employed for the prevention of corrosion on Duralumin. These methods naturally form into two groups. In the first place it is quite possible to avoid corrosion completely by protecting the surface of the metal with paint or varnish or enamel, whilst in the second place it is possible by electro-chemical means to deposit on the surface of the metal a film of a protective nature. Duralumin lends itself fairly readily to protection by organic means, and this aspect of the problem, therefore, becomes simply one of providing a suitable paint, varnish or enamel. This is scarcely a metallurgical matter. It is quite well established that certain types of varnish do provide adequate protection against corrosion for Duralumin even under quite adverse conditions. There is always a tendency in aeronautical work to skimp the varnish with the intention of saving weight, but it appears that some of the better classes of varnish give adequate protection without any undue thickness of coating being rendered necessary. If stove enamels are being employed with Duralumin it is important to utilise an enamel that stoves at a reasonably low temperature. The majority of such stoving enamels need not be heated to a temperature greater than 160° C., and such a temperature has no deleterious effect upon the metal. If Duralumin is heated to a temperature as high as 200° C. for any appreciable time, there is little danger of a lowering of the maximum stress, but the normal metal tends to become

more brittle. The whole problem, therefore, of protecting Duralumin against corrosion by organic means becomes one of the technique of the paint and varnish manufacturer, and the skill in applying the covering.

The use of electro-chemical means for protecting Duralumin is not a very simple matter. Duralumin, like its parent metal aluminium, is not a suitable metal onto which to deposit a film of another metal. The electro-plating of aluminium and its alloys is exceedingly difficult. It is not impossible to plate the metal, but the difficulties encountered are intense, so much so that the production of a protective film over the whole surface of, say, a spar is an operation requiring very great skill together with some good fortune. Up to the present the difficulties have been sufficiently great to render it almost impossible to utilise this method in a practical way. The process of electro-deposition is also at a disadvantage in that such metals as can be deposited upon Duralumin for the purpose of protecting it against corrosion are necessarily heavier than the basis material. This consideration has no particular force when the article to be treated is a heavy forging or casting, but a thin structural part made from Duralumin may be increased in weight by quite a considerable percentage if an adequate protective layer of zinc, cadmium, or nickel is applied. This is one respect in which the organic protectives are markedly superior to electro-deposited films.

Quite apart from the formation of a film of protective metal it is possible to produce a very useful film upon Duralumin by the anodic oxidation process. This method, which has been patented by the Department of Scientific and Industrial Research, produces upon the surface of the metal a film of oxide, which, if properly made, is quite continuous. Although the film has but a very small thickness, it is sufficiently powerful as a resistant to corrosion to afford a very distinct protection to the metal. The coating is so thin that its weight can be neglected entirely. The coating is not suitable to resist severe deformation, and it is essential, therefore, that the anodic oxidation process shall be carried out when all mechanical and heat treatment of the Duralumin has been completed.

For aircraft purposes it appears, therefore, that the most satisfactory process for the permanent protection of Duralumin is to produce an anodically oxidised layer upon the metal and then to cover the completed structure with a suitable varnish or enamel. The anodic layer is an efficient protection by itself, but it is scarcely practical to attempt to produce such a layer over the whole of the surface of a built-up structure. Riveted joints, screwed holes, etc., are usually outside the scope of the practical application of anodic oxidation. These are essential to the type of structure under consideration, and it is upon them that the organic protectives must be applied. To avoid a patched-up job, however, it is preferable to use a varnish or enamel over the whole of the structure.

It has been pointed out above that it is preferable to protect Duralumin against corrosion during the whole of its life, and this means that the material should be protected temporarily whilst it is lying in store, or after fabrication, and prior to the application of the final protective covering. The protective coating that is selected for this purpose is largely a matter of taste. Experience goes to show that a thin layer of ordinary machine oil provides a quite adequate protection. This can be applied by wiping over the whole of the surface of the metal with engine waste dipped in oil, or, if it is preferred, the material can be dipped into a tank of oil and the excess allowed to drain away. Material which has been treated in this way should be inspected periodically, say, once in three months, and the coating of oil renewed. Of course, if the material is handled in such a way that it may lose its protective film, the covering should be renewed before the material is returned to store. As has been stated above, Duralumin does not corrode very easily, and unless the conditions to which it is exposed are exceedingly severe, there is no need to utilise any special method of protecting Duralumin from corrosion. Any agent which keeps moisture away from the surface of the metal is quite adequate as a preventive of corrosion, and the method suggested above certainly gives satisfactory results in practice.

(To be continued.)

TECHNICAL LITERATURE.

A.R.C. REPORTS.

MEASUREMENT OF THE ROTARY DERIVATIVE M_q ON THE 1/5th SCALE MODEL BRISTOL FIGHTER IN THE DUPLEX WIND TUNNEL.

By E. F. RELF, A.R.C.Sc.

R. and M. No. 978. (15 pages and 12 diagrams). June, 1925. Price 1*s*. net.

For determining the stability of an aeroplane in a fore and aft direction the most important quantity required is the rotary derivative M_q which gives the rate of change of moment with pitching velocity. This derivative has here been determined for the Standard Bristol Fighter. The work forms part of a general programme of experiments to determine all the important forces and derivatives for the 1/5th scale model Bristol Fighter with airscrew running.

The derivative M_q has been measured with the standard small tail plane and with the large tail plane in use for the Royal Aircraft Establishment full-scale stability experiments, over an angle range from -4 to $+36°$ and at all working values of V/nD. Measurements with airscrew stopped, with airscrew removed, and will tail plane removed, are also given. Mean downwash at the tail plane has been measured under all the above conditions to provide data for the "lag" correction.

At angles below stalling no difficulties were encountered and the accuracy of measurement was good. Above the stall the accuracy is much poorer, and the validity of the correction for "lag" is open to doubt. Nevertheless, the results are of great value, being the first to be obtained on M_q above the stall, and being urgently required for work on the control of stalled machines.

The measurements, especially above the stall, should be checked as soon as opportunity arises, by similar tests on the whirling arm. The whirling arm eliminates the lag correction, and has the further advantage that the angular velocity q is constant. The variation of q during an oscillation may influence the results above the stall, but is unlikely to do so at normal angles.

ON THE NECESSARY SIZE OF AERODROMES IN ORDER THAT A LANDING MAY BE MADE IF THE ENGINE FAILS WHEN GETTING OFF.

By H. GLAUERT, M.A.

Presented by the Director of Scientific Research.

R. and M. No. 996 (Ae. 208). January, 1926. (10 pages and 5 diagrams). Price 6*d*. net.

This investigation was undertaken in order to obtain a rough estimate of the size of aerodrome necessary in order to allow an aeroplane to land on it if engine failure occurred at any time during getting off, with special reference to the two cases: (1) when the aeroplane continues to fly in its original direction; (2) when the aeroplane climbs on a steady turn and then turns back into wind when the engine fails. A comparison of the results of these two cases shows that an important saving in the necessary size of the aerodrome can be secured by the turning climb, but the size of aerodrome indicated is larger than current practice unless the stalling speed and power loading are limited.

Curves are given showing the necessary size of aerodrome in terms of stalling speed and power loading of the aeroplane. In particular, the required size of the aerodrome was found to decrease as the angle of climb increases and as the stalling speed decreases.

These Reports are published by His Majesty's Stationery Office, London, and may be purchased directly from H.M. Stationery Office, at the following addresses: Adastral House, Kingsway, W.C. 2; 28, Abingdon Street, London, S.W. 1; York Street, Manchester; 1, St. Andrew's Crescent, Cardiff; or 120, George Street, Edinburgh; or through any bookseller.

THE ROYAL AIR FORCE

London Gazette, June 15, 1926

General Duties Branch

Flight-Lieut. F. L. Hopps, A.F.C., is granted a permanent commn. in this rank; June 1. The following Flying Officers are transfd. to Reserve, Class A:—J. F. Dewar; June 14. J. T. Hall; June 16. Flying Officer G. C. B. Bernard-Smith resigns his permanent commn.; June 6.

Stores Branch

Flight-Lieut. J. V. Mason is granted a permanent commn. in this rank with effect from June 2, and with seny. of February 19, 1923 (substituted for *Gazette* June 4). Flight-Lieut. C. Harvey is transfd. to Reserve, Class C, and is granted permission to retain rank of Sqdn.-Leader; June 17. Flying Officer St. J. F. Wintour relinquishes his short service commn. on account of ill-health; June 16. Flying Officer F. W. van Blommestein is dismissed the service by sentence of Field General Court-Martial; March 27.

Medical Branch

The following are granted short service commns. as Flying Officers, for three years on active list, with effect from and with seny. of dates indicated: S. F. Heatley, M.B., B.A.; June 2. P. H. Perkins; June 1. Flight-Lieut. W. E. Hodgins, M.B., is promoted to rank of Squadron-Leader; June 15. Flying Officer S. S. Proctor, M.B., is transfd. to Reserve, Class D.2; June 17.

Memorandum

The permission granted to Sec. Lieut. T. S. Hill to retain rank is withdrawn on his enlistment in Supplementary Res., Army; May 25.

Reserve of Air Force Officers

F. G. Wayman is granted a commn. in Class A.A., Gen. Duties Branch, as a Pilot Officer on probation; June 1. The following Flying Officers are transfd. from Class A to Class C.:—E. O. Fuller; May 1. J. F. A. Baker; June 10. D. M. Deighton; June 15. Flying Officer C. R. H. Trevor is transfd. from Class B. to Class C.; June 10. The following officers relinquish their commns. on completion of service:—Flight-Lieut. P. A. F. Belton, Flying Officer J. R. Astin; April 20. Flying Officer R. Jarman, D.S.C.; May 1. Flying Officer P. D. Robins, A.F.C.; May 8. Flying Officer L. A. Wingfield, M.C., D.F.C.; May 29.

ROYAL AIR FORCE INTELLIGENCE

Appointments.—The following appointments in the Royal Air Force are notified:—

General Duties Branch

Squadron Leaders: R. S. Booth, A.F.C., to No. 5 Flying Training Sch., Sealand; 21.6.26. J. Everidge, M.C., to No. 2 Armoured Car Co., Palestine; 11.6.26. W. H. Dolphin, to Inland Water Transport, Iraq; 11.6.26.

Flight-Lieuts.: H. G. P. Ovenden, to No. 4 Flying Training Sch., Egypt; 23.5.26. L. V. Hirst, to R.A.F. Depot, Uxbridge, on transfer to Home Estab.; 28.5.26. R. E. H. Daniel, to R.A.F. Depot, Uxbridge, on transfer to Home Estab.; 24.5.26. C. R. Steele, D.F.C., to R.A.F., Staff College, Andover; 4.6.26. F. H. D. Henwood, D.F.C., No. 19 Sqdn., Duxford; 21.6.26. F. O. Soden, D.F.C., to H.Q., Spec. Res. and Aux. Air Force; 30.6.26. D. Gilley, D.F.C., to Aden Flight; 2.6.26. E. H. Attwood, to R.A.F. Depot, Uxbridge, on transfer to Home Estab.; 4.6.26. J. E. MacLennan, to No. 2 Flying Training Sch., Digby; 28.7.26.

Flying Officers: E. J. Protheroe, to H.Q. Air Defence of Great Britain, Uxbridge; 3.6.26. (Hon. Flight-Lieut.) V. J. Somerset-Thomas, to No. 5 Flying Training Sch., Sealand; 8.6.26. C. Mackenzie-Richards, to Experimental Section R.A.F., Farnborough; 31.5.26. E. H. Alliott, to No. 22 Sqdn., Martlesham Heath; 27.6.26. A. E. Golds, to No. 2 Flying Training Sch., Digby; 27.4.26. H. P. Morris, to R.A.F. Depot, on transfer to Home Estab.; 21.5.26. R. T. Taaffe, to H.Q. Fighting Area, Kenley; 5.7.26. A. G. Boon, to No. 13 Sqdn., Andover; 15.6.26. J. Hadden, to No. 2 Sqdn., Manston; 15.6.26. W. A. D. Brook, to No. 13 Sqdn., Andover; 11.6.26. (Hon. Flight-Lieut.) P. I. V. Rippon, to Home Aircraft Depot, Henlow; 14.6.26. L. W. Park and A. M. Rowe, to R.A.F. Depot, Uxbridge, on transfer to Home Estab.; 4.6.26. A. M. Glover, to R.A.F. Depot, Uxbridge, on transfer to Home Estab.; 30.5.26. W. J. E. Rodwell and G. H. Rawlinson, to R.A.F. Depot, Uxbridge, on transfer to Home Estab.; 22.5.26. G. Terrell, to R.A.F. Depot, Uxbridge, on transfer to Home Estab.; 28.5.26.

Pilot Officers: A. C. Watkins, G. H. C. Ingle, T. K. Merrett and R. A. Wills, to No. 16 Sqdn., Old Sarum; 15.6.26. E. L. Drew and H. J. F. Kempthorn, to No. 58 Sqdn., Worthy Down; 15.6.26. E. J. George, to No. 39 Sqdn., Spittlegate; 15.6.26. S. J. Gilbert, A. W. Whitta and J. N. Young, to No. 4 Sqdn., S. Farnborough; 15.6.26. J. D. Greaves and D. S. Thomas to No. 99 Sqdn., Bircham Newton; 15.6.26. P. E. Grenfell and J. W. Stokes, to No. 13 Sqdn., Andover; 15.6.26. A. V. Harvey, to No. 9 Sqdn., Manston; 15.6.26. W. T. Jones, to No. 9 Sqdn., Manston; 29.6.26. F. W. H. Hall, J. C. Lewis and G. H. Walker, to No. 2 Sqdn., Manston; 15.6.26. A. E. Hill, to No. 2 Sqdn., Manston; 29.6.26. F. S. Hodder, to No. 13 Sqdn., Andover; 29.6.26. S. F. Prince, to No. 207 Sqdn., Eastchurch; 15.6.26. F. G. S. Wilson, to No. 2 Sqdn., Manston; 15.6.26.

Air Mail to Morocco and Algeria

THE Postmaster-General announces that it has been found necessary to increase the rate of special air fee payable (in addition to ordinary postage) on air mail letters for Morocco and Algeria. The revised rates are as follows:—Up to ½ oz., 4d.; up to 3½ oz., 8d.; for each additional 3½ oz., or fraction thereof, an additional 4d.

K.L.M. Fokkers for Switzerland

A FLEET of five Fokker monoplanes, which have hitherto been in service on the K.L.M. London-Amsterdam air route, have been sold to a Swiss air transport company, and were flown recently, in formation, from Holland to Basle. As previously announced in FLIGHT, the old F VII type Fokker monoplanes of the K.L.M. are being replaced by the new type Fokkers fitted with Bristol "Jupiters."

Royal Air Force Flying Accident

THE Air Ministry regrets to announce that as the result of an accident at Northolt, Middlesex, to a Siskin of No. 41 Squadron, Northolt, on June 16, Flying Officer Anthony Clifford Addams, the pilot and sole occupant of the aircraft, was killed.

FOR THE R.A.F. DISPLAY AT HENDON: This three-quarter front view of the Fairey "Firefly" shows this machine to be the logical development, in single-seater form, of the Fairey "Fox." The engine is a Fairey "Felix." This machine is probably the fastest single-seater fighter in this country at the present time.

LIGHT 'PLANE CLUB DOINGS

London Aeroplane Club

THE total flying time for the week was 50 hours 15 mins. Flying instruction was given to the following Members :—G. W. Quirk, A. R. H. Stewart, O. J. Tapper, F. S. Adams, G. Eady, G. H. Craig, G. W. Hall, J. H. Saffery, B. B. Tucker, J. C. Parkinson, E. A. Cook, K. V. Wright, P. O. A. Davison, J. H. S. Garne, Miss O'Brien, J. A. Simson, H. Kennedy, J. S. M. Michie, Jones, L. G. Sykes, S. M. Nesbitt, A. L. Angus, J. Barros, A. J. Richardson, Wall, E. D. Moss, R. Malcolm, G. N. Howe, Capt. Godfrey, G. Black.

The following Members made *solo flights* :—L. J. C. Mitchell, H. Kennedy, N. Jones, W. Roche Kelly, S. O. Bradshaw, J. Barros, E. D. Moss, A. P. Hunt, R. Malcolm, W. Hay, Major K. M. Beaumont, E. S. Brough, G. Wallcousins, Squadron-Leader M. E. A. Wright, A. Lees, G. W. Quirk, O. J. Tapper, N. J. Hulbert, G. H. Craig, A. G. D. Alderson.

The *following* Associate Members were given joy-rides :—A. L. A. Petty, Miss Oldham, Mrs. M. E. A. Wright, Miss Salusbury, G. Valpy.

On Monday, June 14, L. J. C. Mitchell completed successfully the flying tests for his Aviator's *Certificate.*

Instruction in Navigation.—Instruction in navigation will be given to Members by the Pilot Instructors and for this purpose the Club machines will be flown outside the three-mile limit. The charge will be at the rate of £2 10*s*. per hour. Minimum time, 30 mins. Maximum time, 1 hour.

Purchase of Machines.—The following donations have been given towards the cost of the new machine :—

Squad.-Leader M. E. A. Wright, £18 ; Capt. W. Roche Kelly, £10 ; Mrs. G. G. Black, £3 ; T. C. Sharwood. £2 ; E. Cooper, £1 ; S. H. J. Garne, £1 ; F. C. Elford, £1 ; N. J. Hulbert, £1 ; Donations previously announced, £701 5*s*. Total, £738 5*s*.

Mrs. Eliott-Lynn has now received her "B" Licence.

The Lancashire Aero Club

THE weather has been good. Machines in use GEBLR, GEBLV and GEBMQ. Mr. Stack gave instruction to :—H. Hardy, 2 hours 10 mins. ; J. Leeming, 1 hour 40 mins. ; — Fallon, 1 hour 40 mins. ; A. Benson, 1 hour 30 mins. ; H. P. Hall, 1 hour 10 mins. ; A. Abdulla, 55 mins. ; F. Anderson, 45 mins. ; A. Goodyear, 35 mins. ; Dr. Wade, 30 mins. ; F. Collinson, 30 mins. ; B. Leigh, 35 mins. ; C. Bert, 35 mins. ; Sir John Rhodes, 35 mins. ; H. Rodman, 20 mins. ; C. Agar, 20 mins. ; F. Barnes, 15 mins. ; F. Gattrell, 15 mins. ; P. Michelson, 10 mins. ; H. Scott, 10 mins. Total, 14 hours 40 mins.

Mr. Cantrill :—P. Michelson, 30 mins. ; H. Brown, 30 mins. ; J. Leeming, 25 mins. ; A. Lilley, 25 mins. ; A. Benson, 15 mins. Total, 2 hours 5 mins.

Mr. Scholes :—D. F. Davison, 40 mins. ; A. Crosswaite, 35 mins. ; H. Stern, 20 mins. ; H. Hardy, 20 mins. ; P. Michelson, 15 mins. Total, 2 hours 10 mins.

Solo Flights by :—P. Michelson, 1 hour 15 mins. ; M. Lacayo, 30 mins. ; R. Williams, 25 mins. ; J. Leeming, 25 mins.

Tests occupied 1 hour 50 mins. Joy rides 1 hour 50 mins. Total solo 2 hours 35 mins. Dual total 18 hours 55 mins. Total for week 25 hours 10 mins.

Members are reminded that teas may be obtained at the Club House. The Avro 504K with 80 Renault engine will be delivered early in July, after being entirely rebuilt by Messrs. A. V. Roe & Co., Ltd. The cost of this work has been found by the Petrol Companies' gift of £200. On Sunday, June 20. Mr. Michelson did the tests for his "A" Licence.

The Midland Aero Club

REPORT for week ending June 19.—The total flying time for the week was 10 hours 30 mins.

The following Members had flying instruction :—L. N. Goodway, R. Jackson, S. Savage, A. R. H. Miller, E. Beard, W. Swann, S. Smith, E. King, T. Gibbons, L. Knox flew solo. Two test flights occupied 30 mins ; one joy-ride, 19 mins.

The necessary new engine parts having been received from the A. D. C. on Thursday, E.B.L.T. is now in commission again.

Unfortunately, solo flying this week has been considerably restricted owing to the present uncompleted stage of the Air Ministry work on the Aerodrome in preparation for the formation of an Auxiliary squadron.

A number of members hope to visit the R.A.F. Display, on July 3, and Croydon on the following day. A Club Badge is being prepared and will be circulated to Members shortly.

The Club recently had the honour of having three Hawker Woodcocks, belonging to No. 3 Fighter Squadron R.A.F. housed in their hangar for three weeks. These machines were stationed here for the Birmingham Torchlight Tattoo.

The Newcastle-upon-Tyne Aero Club

REPORT for week ending June 20.—No flying took place on Monday and Tuesday owing to torrential rain. Only one machine, G-EBLY, was in service, LX still being without an engine, though one is expected early in the coming week. Total time for the week :—30 hrs. 40 mins. ; dual, 11 hrs. 5 mins. ; *solo*, 15 hrs. 50 mins. passenger, 1 hr. 50 mins. ; tests, 30 mins.

The following members flew under instruction : Miss Leathart, Messrs. Stawart, Bruce, Twine, Phillips, Dixon, Howard, Leete. Secondary dual : Messrs. MacMillan, C. Thompson, R. N. Thompson, N. S. Todd. *Solo* : Messrs. MacMillan, C. Thompson, R. N. Thompson, Bruce, Dixon and Phillips. Passengers : Miss Stawart, Miss Reece.

On Sunday night, at about 10 p.m., Mr. A. D. Bruce made his first solo flight, putting up a very good performance. Mr. Bruce has been one of the "*probables*" for some time, but has always contrived to take his instruction on days when it was not suitable to make first solo flights.

On Thursday, Major Packman, with Mr. F. Howard Phillips as passenger, flew to Belsay Castle, *where some 180 crippled children were being entertained* by the Sunderland Rotary Club, and Mr. Hugh Middleton, O.B.E. After throwing out three large parcels of toys, each parcel being attached to a small parachute, a landing was made at a pre-arranged spot near to the Castle.

D'Oisy's Dash Completed

CAPT. PELLETIER D'OISY (and with him his mechanic Carol) has concluded his remarkable aerial dash to the East, although he has not made Tokyo his goal as at first planned. After his 4,500 miles from Paris to Irkutsk in five days, he lost no time in proceeding on his journey on June 15, when he flew from Irkutsk to Harbin and Chita. The next day he completed the seventh stage to Mukden, and on June 18 he arrived in Peking, where he decided to bring his flight to a close. D'Oisy has thus completed a flight from Paris to Peking, a distance of, roughly, 6,500 miles in eight days. He accomplished this flight on a Breguet type IXX biplane —a machine that has made a name for itself in connection with long-distance flights. D'Oisy stated that it was a strenuous flight, especially over the Ural mountains, and in parts of Siberia.

British-Built Autogyro Tested

THE first British-built Cierva "Autogyro," constructed for the Air Ministry by A. V. Roe, Ltd., was given its first official flying tests at Hamble on June 22. This new "Autogyro"—which will form a "star" turn at the forthcoming R.A.F. Display at Hendon—is similar in most respects to the model demonstrated at Farnborough last October, particulars of which were published in FLIGHT at the time, but is fitted with a 130-h.p. Clerget and possesses certain improvements in details and construction. Its pilot was Mr. F. T. Courtney, who once again demonstrated its extraordinary qualities—on one occasion attempting an almost vertical descent on to a newspaper, only missing his ground mark by a few yards.

Lancashire Aero Club Display

As the date (July 11) originally fixed for the flying display at Woodford, organised by the Lancashire Aero Club—reference to which has already appeared in FLIGHT—rather clashes with the R.A.F. Display and the Aerial Derby, the L.A.C. has decided to postpone their Display until September 26.

By-the-way!

SOME of our readers may be interested to know that the "Cellon" dope and the "Mallite" (Aeronautical and Panel Plywood Co., Ltd.) plywood used on the four Fairey IIID (Napier "Lions") biplanes maintained their excellent reputations throughout the big R.A.F. flight just completed.

PUBLICATIONS RECEIVED

Radial Air-Cooled Aero Engines : with Special Reference to the "Bristol" Jupiter Engine. Three papers by A. H. R. Fedden. The Bristol Aeroplane Co., Ltd., Filton, Bristol.

The Original Book of the Ford. 10th Edition. Temple Press, Ltd., 7-15, Rosebery Avenue, London, E.C.1. Price 2*s*. 6*d*. net. Post free, 2*s*. 10½*d*.

Twenty-Fourth Annual Report. Transactions of the Year 1925. The Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, London, S.W. 1.

The Accessory. May-June, 1926. *Vol.* 12, *No.* 127. Brown Brothers, Ltd., Great Eastern Street, London, E.C. 2.

AERONAUTICAL PATENT SPECIFICATIONS

Abbreviations : Cyl. = cylinder ; i.c. = internal combustion : m. = motor. The numbers in brackets are those under which the Specifications will be printed and abridged, etc.

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Published June 24, 1926

2,995. R. ESNAULT-PELTERIE. Hydraulic change-speed devices. (228,536.)
4,849. T. F. ROBERTS and G. A. REEDER. Control of aeroplanes. (252,433)
5,058. F. M. T. REILLY. Airscrews. (252,442.)
6,448. DE HAVILLAND AIRCRAFT CO., LTD., and G. DE HAVILLAND. Separators for wires, rods, etc. (252,489.)
10,311. AIRSHIP GUARANTEE CO., LTD., and B. N. WALLIS. Mooring masts (252,517.)
13,468. A. TAMMEO, E. CAMINADA, P. FOPPIANO and C. SCOTTI. 'Planes. (236,178.)
26,960. A. MCLEAN. Anti-glare device for goggles. (252,611.)

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